Travel Behavior, Emissions & Land Use Correlation Analysis

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What was the purpose of this study?

To better understand relationships between land-use patterns, mode choice and vehicle emissions in the Central Puget Sound Region.

- Describe how land use mix, density & street connectivity where people live and work influence trip chaining and mode choice.

- Estimate linkages between land use and household generation of oxides of nitrogen & volatile organic compounds (ozone precursors).

Outcomes

- Provides detailed trade-offs between levels of land use mix, street network connectivity, and density and the choice to take transit, walk, bike, drive alone, or carpool

- Controls for demographic and cost factors associated with specific modes of travel

- Provides new information that can be applied within regional & local land use & transportation decision-making processes

What was different about this study?

- **Level of Detail in Measurement**

  - Parcel-level land use data
  - Link-based emissions analysis

- **Tour-based Modeling Approach**

Data Used

- 1999 PSRC Household Travel Survey (travel behavior)

- Land use parcel data for 4 counties

- PSRC travel demand model traffic analysis zones (travel speeds, roadway classification)

- Transit agency bus stop network

Measuring urban form, transportation and emissions

Calculated urban form, transportation and emissions measures for every trip in PSRC Survey

Raw land use measures

- Number of parcels
- Acres of land
- Square feet of building floor area

Final urban form measures

- Net residential density
- Retail floor area ratio
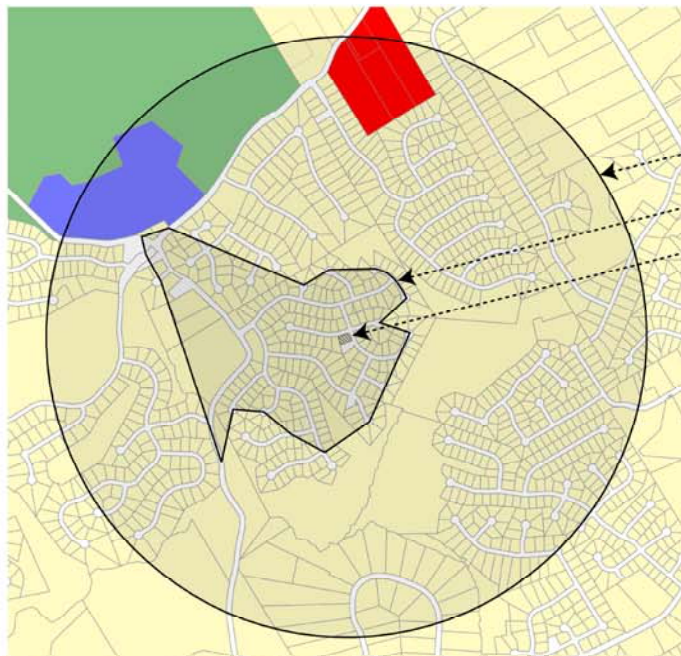- Mix of uses

Transportation measures

- Intersection density
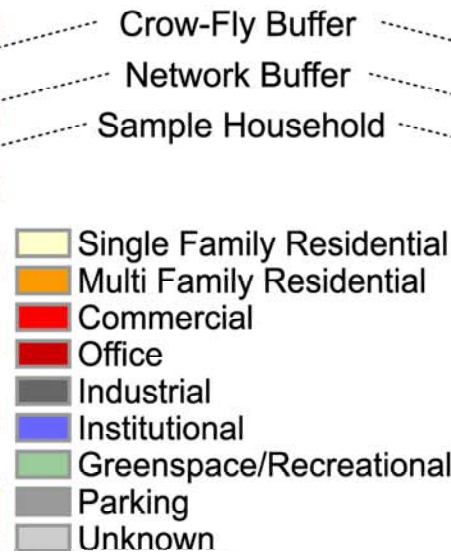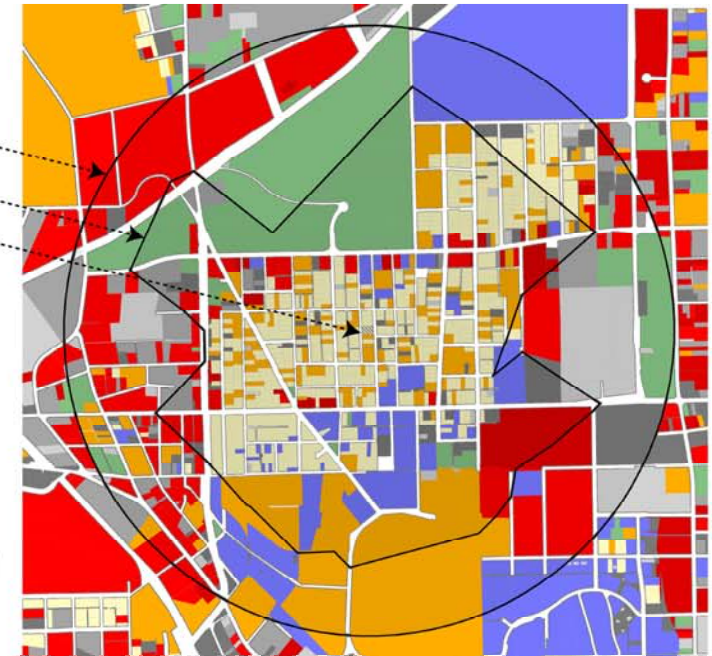- Bus stop density

Emissions measures

- Travel time/speed based on roadway classification for each link of the trip, time of day

Calculating urban form & transportation measures

Disconnected   Connected

Crow-Fly Buffer
Network Buffer
Sample Household

Single Family Residential
Multi Family Residential
Commercial
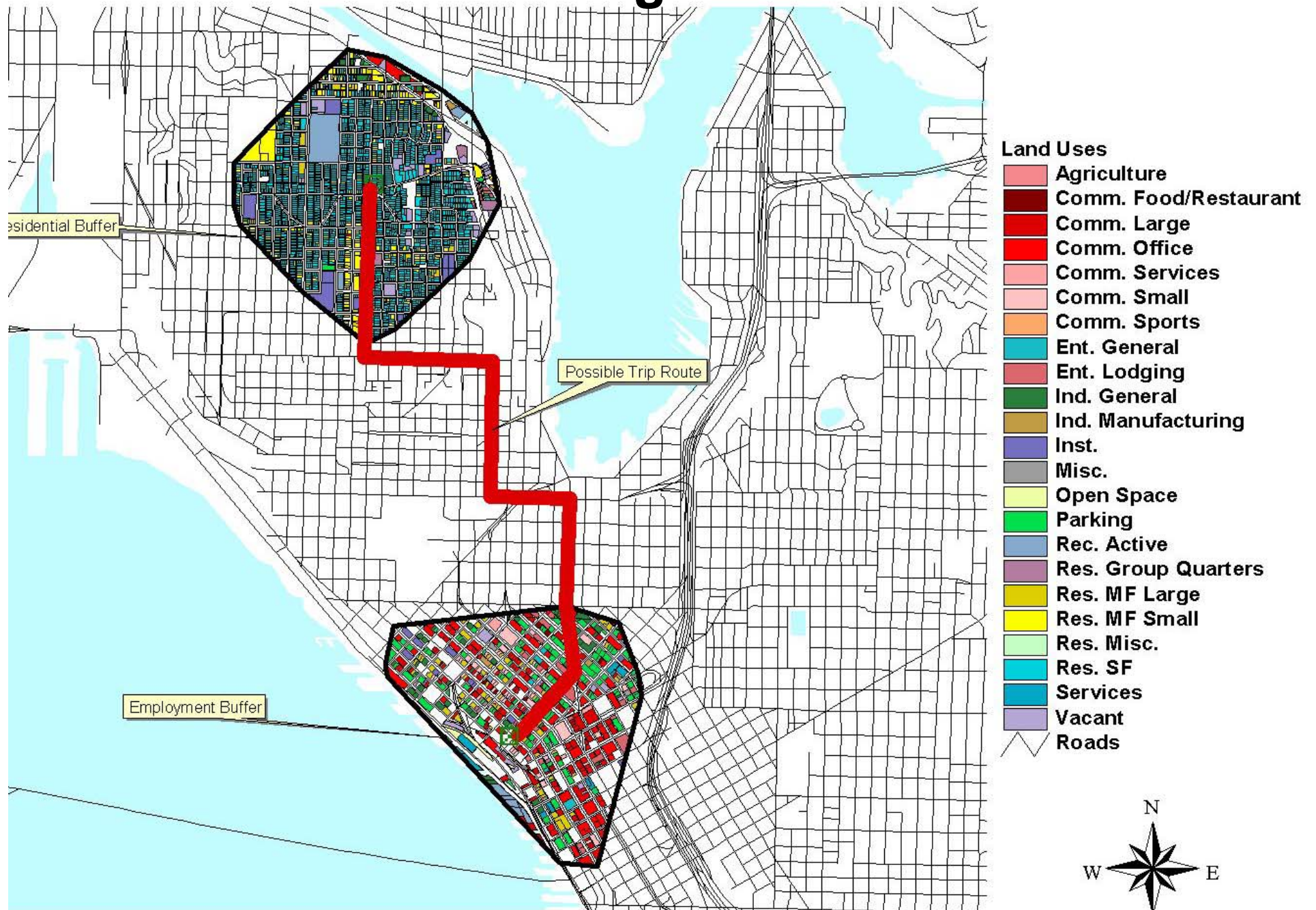Office
Industrial
Institutional
Greenspace/Recreational
Parking
Unknown

Calculated measures within a 1-km *road network buffer* for each origin and destination in the survey

Calculating Emissions

Residential Buffer

Possible Trip Route

Employment Buffer

Land Uses
- Agriculture
- Comm. Food/Restaurant
- Comm. Large
- Comm. Office
- Comm. Services
- Comm. Small
- Comm. Sports
- Ent. General
- Ent. Lodging
- Ind. General
- Ind. Manufacturing
- Inst.
- Misc.
- Open Space
- Parking
- Rec. Active
- Res. Group Quarters
- Res. MF Large
- Res. MF Small
- Res. Misc.
- Res. SF
- Services
- Vacant
- Roads

N
W   E

Tour-Based Analytical Approach

Trips in PSRC Survey linked into 3 tour types:
- Home-based work
- Home-based other
- Work-other-work (mid-day subtours)

Based on concept that mode choice is impacted by *all* activities (destinations) within a tour
- You drive to work because you need to pick up your child on the way home
- You take the bus because you can walk to the bank at lunchtime

Linking Trips Into Tours

Example tour consisting of four separate trips

- home to day care
- day care to work
- work back to day care and then finally -
- back home!

Key Variables

Socio-demographic (controlled)
- Income
- Vehicles per household
- People per household
- Age

Urban form
- Net residential density
- Retail floor area ratio
- Mix of uses
- Intersection density
- Distance to nearest bus stop

Modes
- Transit
- Walk
- Bike
- Drive Alone
- Carpool

Costs
- Travel time
- Mode Specific Costs

Summary of Results – Urban Form

Urban Form Matters …

(but maybe differently than we thought)!

- Urban form was found to be a ***stronger*** predictor of trip making patterns than demographic factors
- Trip tour structure highly correlated to urban form
- Work environments highly correlated to travel choice

Summary of Results

A New Role for Density:

Residential density did NOT correlate significantly with travel choice

- In previous studies density may have acted as a proxy for other variables, such as mix and connectivity, that are more difficult to measure

Retail density WAS found to be quite significant, in addition to mix of uses and intersection density

Summary of Results - Emissions

Urban Form was found to be a significant predictor of emissions, *even when controlling for distance traveled.*

Longer distances required to travel in more suburban environments were found on the whole to be more polluting than the shorter, more frequent trips correlated with more urban environments

Elasticities: Estimating Potential Change

A 10% increase in…	Is correlated with…	For these kinds of tours
Destination retail density	3.4% increase in transit	Homebased Other
Destination mix of uses	3% increase in transit	Homebased Other
Home intersection density	2.4% increase in transit 2.8% increase in walk	Homebased Other
Destination intersection density	2.3% increase in transit 2.7% increase in walk	Homebased Other
Destination retail density	4.3% increase in transit	Homebased Work
Home retail density	1.2% increase in walk	Homebased Work
Home mix of uses	2.2% increase in walk	Homebased Work
Home intersection density	4.3% increase in walk 8.4% increase in bike	Homebased Work Homebased Work

Elasticities:
Mid-Day Work Based Sub-Tours

- Increases in urban form measures were generally associated with increased demand for walking, but reduced demand for drive alone, carpool and transit

- A slight increase in demand for walking (0.9 to 1.0%) was associated with a 10% increase in work location land use mix of uses and work location intersection density.

VMT & VHT Comparison:
Education Hill (Redmond) & Upper Queen Anne

Variable	Difference btw. Communities (Queen Anne - Redmond)	% Change in Mean Daily Household VMT	% Change in Mean Daily Household VHT
Net Residential Density (dwelling units per acre)	8.13		-4.6%
Intersection Density (per sq km)	53.42	-19.0%	-13.9%
Mixed Use Index (ranges 0 to 1)	0.12	-2.7%	-3.2%

Results application for
local land use planning

- Changing land use where we live & work will increase utility of walking, biking, and transit relative to driving alone.
- Can look at land use codes based on goals for travel behavior
- Insight into multimodal impact fee/concurrency system:
  - Can give quantifiable credit for developments that increase intersection density, mix of uses, or retail density
  - Can develop VHT/VMT based system whereby not only trip generation but also trip distance and travel time are taken into account